I Earthquakes Result from Stress

Topic 1 What Is an Earthquake?

Earthquakes are very common. More than a million occur each year. That is about one every 30 seconds. Most of these are too small to be noticeable on all but the most sensitive earthquake recording instruments. However, more than 3000 earthquakes strong enough to move sections of Earth's crust are recorded each year. Several hundred earthquakes move Earth's surface significant distances, and about 20 cause severe changes.

An **earthquake** is a shaking of Earth's crust caused by a release of energy. Like volcanoes, earthquakes are a result of the motions of the lithospheric plates. However, the area affected by an earthquake is much larger.

A severe earthquake in a populated area can be especially hazardous. Often the collapse of buildings caused by the ground shaking is only the beginning of the devastation. Explosions and fires start from broken electric wires or broken gas mains. Diseases spread when sewage lines are broken and water supplies become contaminated. Food shortages may occur as normal supply routes—roads, railroads, airport runways—become unusable. Coastal locations long distances from the earthquake may flood under the huge waves called tsunamis (Chapter 12, Topic 8). Earthquakes are the most destructive of natural disasters.

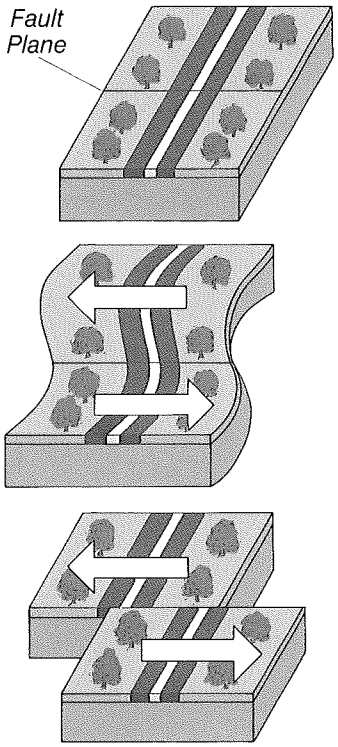
Topic 2 Causes of Earthquakes

Earthquakes can occur for many reasons. The ground can shake from the eruption of a volcano, the collapse of a cavern, or even from the impact of a meteor. However, the major cause of earthquakes is the stress that builds up between two lithospheric plates.

Most of the time, friction between plates prevents movement along the plate boundary. Instead, the stresses cause the plates to deform, or change shape. Eventually, the stresses become great enough to overcome the frictional forces, and the plates suddenly move. This movement causes an earthquake. The plates then snap back to the shapes they had before they were deformed but at new locations relative to each other. This explanation for the cause of an earthquake is called the **elastic-rebound theory** and is fundamental to an understanding of earthquakes.

OBJECTIVES

- **A** Define *earthquake*, list problems caused by earthquakes, and discuss several causes of earthquakes.
- **B** Define *focus* and *epicenter* and identify the significance of the depth of the focus.
- **C** Name and describe the kinds of waves produced by earthquakes.

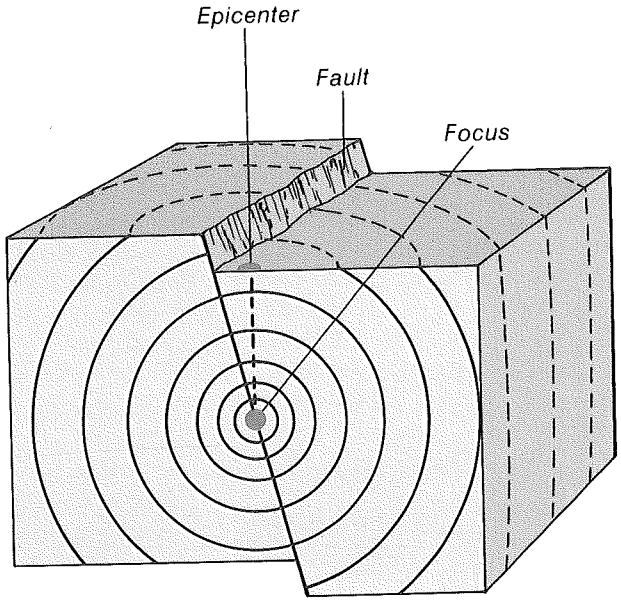


15.1 Earthquakes occur when the stress along a fault plane overcomes the forces of friction. When friction is finally overcome, the plates move suddenly and release earthquake energy. Then the rocks along the plate boundaries snap back to their original shape.

Topic 3 Depth of Earthquakes

The depth inside Earth at which an earthquake occurs depends upon the kind of plate boundary involved. At spreading centers and sliding boundaries, such as the mid-Atlantic Ridge and the San Andreas Fault, most earthquakes are less than 30 kilometers deep. At subduction boundaries, however, where one plate is plunging beneath another plate, earthquakes can be as much as 700 kilometers deep. The plate boundary is also plunging downward, often at about a 45-degree angle. Earthquakes can occur along this boundary until such depths are reached where pressures and temperatures transform rigid rocks into a more flexible material.

The point on the fault plane at which the first movement occurs is called the **focus** of the earthquake. The focus is the source of the energy released by the earthquake and can occur at depths of up to 700 kilometers. The point on Earth's surface directly above the focus is the **epicenter** of the earthquake. The epicenter is the location usually given in news reports.



15.2 The focus is the location of the earthquake within Earth. The epicenter is the point on the surface directly above the focus.

Topic 4 Earthquake Waves

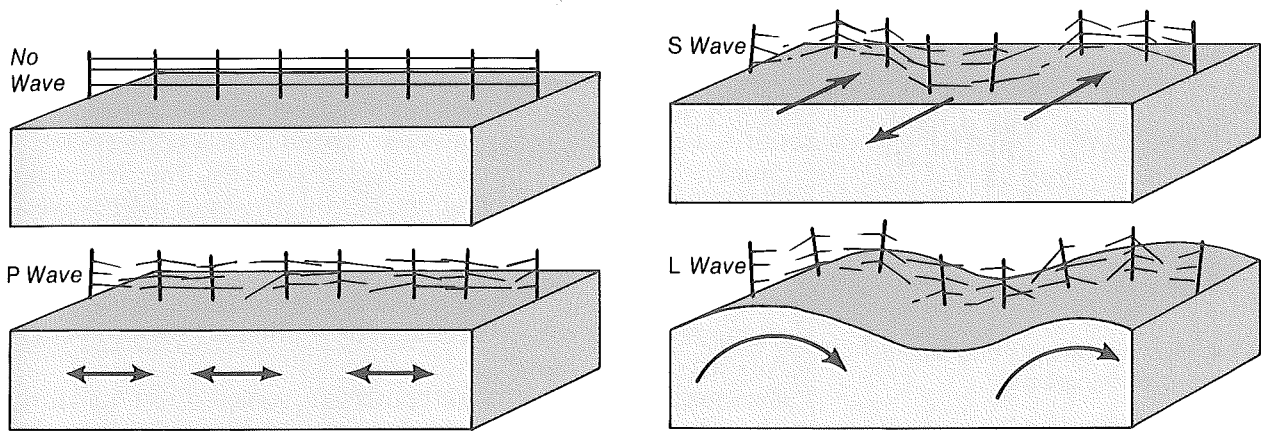
Earthquakes produce three basic kinds of wave motions. One motion moves the particles in the rock back and forth, while a second motion moves the particles side-to-side. The third motion resembles waves in water.

The back-and-forth wave motion alternately squeezes and stretches the rock material through which the wave passes. These waves are called *compressional, primary,* or ***P* waves.** *P* waves can travel through any material—solid rock, magma, ocean water, even through air.

The side-to-side wave causes particles to move at right angles to the direction the waves are traveling. These waves are called *shear, secondary,* or **S waves.** *S* waves can travel through solids but not through liquids or gases. Liquids and gases cannot be sheared apart.

The rate at which *P* waves and *S* waves move through the ground depends upon the type and nature of the rock material. The velocity of these waves is greatest if the rock is rigid and dense but slows as the rock becomes less rigid and less dense. No matter what the material, *P* waves always travel about twice as fast as *S* waves.

Both *P* and *S* waves are called body waves because they travel through the body of Earth. When *P* and *S* waves reach the surface, they set up a third type of wave called *surface waves,* or ***L* waves.** These waves, which move like ripples on a pond, travel more slowly than either *P* or *S* waves.



15.3 *P* waves and *S* waves travel through Earth. *L* waves travel along the surface.

TOPIC QUESTIONS

Each topic question refers to the topic of the same number.

1. **(a)** What is an earthquake? **(b)** How many earthquakes occur worldwide each year? **(c)** Name several forms of devastation and hardship that accompany earthquakes.
2. **(a)** List several minor causes of earthquakes. **(b)** What is the major cause of earthquakes? **(c)** Describe how earthquakes occur, according to the elastic-rebound theory.
3. **(a)** What type of plate boundary has the deepest earthquakes? Why? **(b)** What is the focus of an earthquake? What is the range for focal depths? **(c)** Where is the epicenter of an earthquake?
4. **(a)** How do the particles in a *P* wave move? **(b)** What kinds of materials can *P* waves travel through? **(c)** How do the particles move in an *S* wave? **(d)** What materials can *S* waves *not* travel through? **(e)** How do the speeds of the *P* and *S* waves compare? **(f)** What are *L* waves?